Venus Landsailing Rover

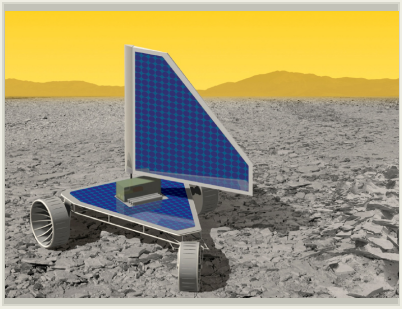
Completed Technology Project (2012 - 2013)

Project Introduction

NASA Glenn has developed electronics and low-power photovoltaics that will continue to function even at the Venus temperature of 450°C. So the fundamental elements of a rover for Venus are not beyond the bounds of physics: we could survive the furnace of Venus-- if we can build a low-power mobility system like a landsail. The surface of Venus is the most hostile environment in the solar system, with a surface temperature hotter than an oven, and a high-pressure, corrosive atmosphere. It is significant that, although humans have sent rovers to Mars with operating lifetimes of eight years and counting, the most capable mission to the surface of Venus has been a stationary lander that survived for only two hours. Exploring the surface of Venus with a rover would be a "stretch" goal, which will push the limits of technology in high-temperature electronics, robotics, and robust systems. In work to develop sensors to work inside of jet engines, NASA Glenn has developed electronics that will continue to function even at the Venus temperature of 450°C. These electronic components represent a breakthrough in technological capability for high temperatures. We have also tested solar cells up to Venus surface temperatures; although the power density produced is low (because of the high cloud levels and thick atmosphere), we can produce electrical power on the surface. So the fundamental elements of a rover for Venus are not beyond the bounds of physics: we could survive the furnace of Venus-- if we can come up with an innovative concept for a rover that can move on extremely low power levels.

Anticipated Benefits

Venus is a scientifically fascinating planet and a mobile exploration rover would produce great public interest. It has been shown by missions to Mars that mobility on the surface is of great value to science exploration, and for a future mission to Venus, it is desired to be able to land a mission with a longer lifetime, and capable of mobility. Exploring the surface of Venus with a rover would be a stretch goal, which will push the limits of technology in high-temperature electronics, robotics, and robust systems. Yet it would be an exciting goal, since Venus is an unknown planet, a planet with significant scientific mysteries, and a planet larger than Mars with equally interesting (although less well known) geology and geophysics. A mission to the surface of Venus would expand our knowledge of the surfaces of terrestrial planets.



Project Image Venus Landsailing Rover

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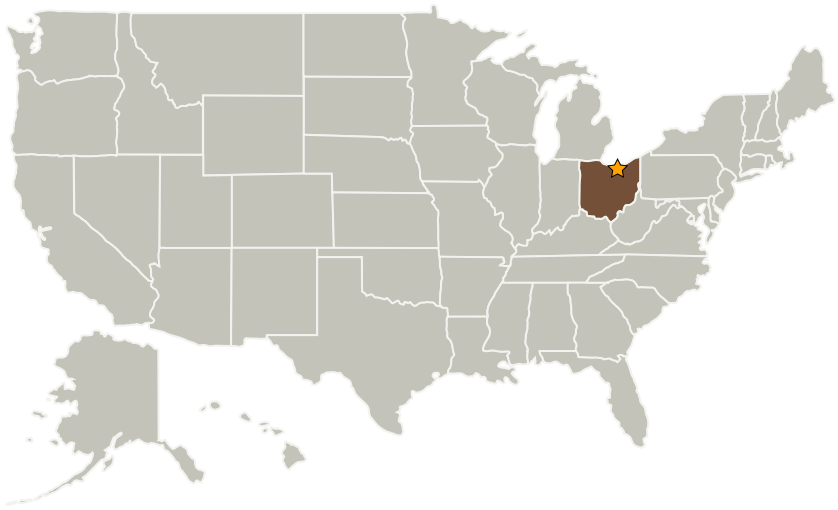


Organizations Performing Work	Role	Type	Location
★Glenn Research Center(GRC)	Lead Organization	NASA Center	Cleveland, Ohio

Primary U.S. Work Locations
Ohio

Project Transitions

September 2012: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Glenn Research Center (GRC)

Responsible Program:

NASA Innovative Advanced Concepts

Project Management

Program Director:

Jason E Derleth

Program Manager:

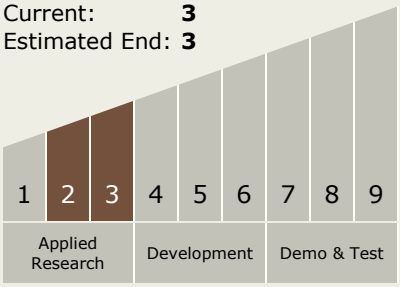
Eric A Eberly

Principal Investigator:

Geoffrey A Landis

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



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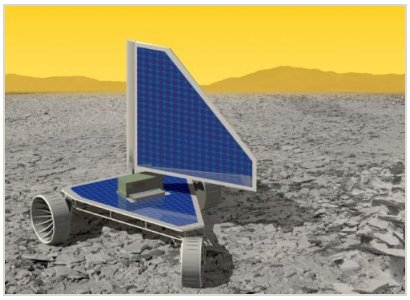
June 2013: Closed out

Closeout Summary: Imagine sailing across the hot plains of Venus! A design f or a craft to do just this was completed by the COncurrent Multidisciplinary Preli minary Assessment of Space Systems (COMPASS) Team for the NASA Innovativ e Advanced Concepts (NIAC) project. The robotic craft could explore over 30 km of surface of Venus, driven by the power of the wind. The Zephyr Venus Landsail er is a science mission concept for exploring the surface of Venus with a mobility and science capability roughly comparable to the Mars Exploration Rovers (MER) mission, but using the winds of the thick atmosphere of Venus for propulsion. It would explore the plains of Venus in the year 2025, near the Venera 10 landing site, where wind velocities in the range of 80 to 120 cm/s were measured by ear lier Soviet landing missions. These winds are harnessed by a large wing/sail whi ch would also carry the solar cells to generate power. At around 250 kg, Zephyr would carry an 8 m tall airfoil sail (12 m2 area), 25 kg of science equipment (mi neralogy, grinder, and weather instruments) and return 2 Gb of science over a 3 0 day mission. Due to the extreme temperatures (450 °C) and pressures (90 ba r) on Venus, Zephyr would have only basic control systems (based on high temp erature silicon carbide (SiC) electronics) and actuators. Control would come fro m an orbiter which is in turn controlled from Earth. Due to the time delay from t he Earth a robust control system would need to exist on the orbiter to keep Zep hyr on course. Data return and control would be made using a 250 MHz link with the orbiter with a maximum data rate of 2 kbps. At the minimal wind speed req uired for mobility of 35 cm/s, the vehicle move at a slow but steady 4 cm/s by p ositioning the airfoil and use of one wheel that is steered for pointing control. Na vigation commands from the orbiter will be based upon navigation cameras, sim ple accelerometers and stability sensors; Zephyr's stability is robust, using a wid e wheel base along with controls to 'feather' or 'luff' the airfoil and apply brakes to stop the vehicle in the case of unexpected conditions. This would be the scien ce gathering configuration. The vehicle itself would need to be made from titaniu m (Ti) as the structural material, with a corrosion-barrier overcoating due to ext reme temperatures on the surface.

Images



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Project Image Venus Landsailing Rover
(https://techport.nasa.gov/image/102205)

Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.3 In-Situ Instruments and Sensors
    - TX08.3.6 Extreme Environments Related to Critical System Health Management

Target Destination

Others Inside the Solar System